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<tr>
<th><strong>Title</strong></th>
<th>Condition Factor, Fat Content and Flavour of Farmed and Wild Salmon</th>
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<tr>
<td><strong>Authors(s)</strong></td>
<td>Schallich, E.; Gormley, T. R. (Thomas Ronan)</td>
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Tests on 882 salmon (587 farmed and 295 wild) indicated that the condition factor (CF) is a useful and easily-measured quality index for salmon, especially when combined with data for skin colour and fat content. Wild salmon were better conditioned than farmed, and CF values of >0.90 are desirable for gutted salmon (wild and farmed) and >0.96 and >0.98 for gut-in wild and farmed fish, respectively. Wild salmon had a slightly lower mean fat content than farmed (12.3 vs 12.5%) but showed more variation in fat content. Tests on three spot samples indicated that taste panels were unable to detect a statistically significant flavour difference between farmed and wild salmon. Comprehensive details of the procedures and results are given below.

Background and tests
Large quantities of Atlantic salmon, both farmed and wild are produced/caught in Ireland. While wild salmon are available, fresh, in quantity, for a relatively short period of the year (mostly June-August), the farmed fish are available fresh all year round. As a result, fresh salmon has now become a commodity product with frequent special offers being mounted by supermarkets. The fresh market requires well-conditioned salmon of uniform size while the salmon smoker has the additional requirement of a narrow range in fat content. While most of the fish on offer are of a high quality, some poorly-conditioned fish find their way onto the market; in addition, the wide range in fat content between fish causes problems for smokers. This study addressed both of these aspects in a series of quality tests on farmed and wild fish which included condition factor, visual condition, fish maturity, fat content and taste panel assessment of flavour (spot samples only). Microbiological and spoilage aspects were not considered.

The fat content of the salmon was measured using a Torry fat meter.
Eqn 1: \[ CF = \frac{\text{fish weight (g) x 100}}{\text{fish length (cm)}} \]

Eqn 2: \[ CF \text{ (farmed) (+gut)} = -0.022 + 1.1184 \text{ CF (-gut)} \]

Eqn 3: \[ CF \text{ (wild) (+gut)} = -0.0471 + 1.1219 \text{ CF (-gut)} \]

The correlation coefficients relating to equations 2 and 3 were +0.997 and +0.992, respectively, indicating a strong relationship between CF (+gut) and CF (-gut). The 50 farmed fish had a higher mean gut content (8.7%) than the wild salmon (7.1%).

CF data on test samples

The CF was measured on three sets of samples, as follows: 308 farmed salmon measured (-gut) at retail outlets (set 1); 279 farmed salmon measured (-gut) at a fish farm (set 2); and 295 wild salmon measured (+gut) at retail outlets (set 3). The set 2 fish were selected to include a wide range in condition in order to assess the spread in CF values. The results showed that wild salmon had a higher mean CF value than farmed (Table 1) and had less variation (lower standard deviation). The selected (set 2) farmed fish had the lowest CF value but the highest variation. The spread in the data is shown in Tables 2 and 3 and the largest proportion of farmed fish were on the 0.90 to 1.05 CF category (Table 1). On the basis of these tests it is advocated that the CF (-gut) should be >0.90 for both wild and farmed salmon and the CF (+gut) >0.98 (for farmed) and >0.96 (for wild). These break-points could be used by producers and retailers as indices of ‘acceptance/rejection’ for individual fish and the results show that 14.9% of the farmed-retail (set 1) fish, 29.7% of the farmed-fish farm (set 2) fish, and 0.6% of the wild salmon (set 3) (see Tables 2 and 3) would be rejected on a CF basis.

The farmed-retail and wild-retail salmon were similar in length and weight (mean values) but the wild fish had the widest variation (Table 4) of these two. The farmed-fish farm samples which were selected to ‘cover’ a wide range in CF...
Excessive swimming than farmed fish

The variables skin colour, visual condition, length, weight, fat and CF were correlated with each other for the three sample sets. The coefficients were small, thus indicating an inability to predict one variable from another; only four values were >0.70, i.e. weight x length = 0.87, +0.91 and +0.95 for farmed-retail, farmed-fish farm and wild-retail samples respectively, and +0.73 for visual condition x weight for farmed-fish farm samples.

Flavour, colour, texture
Twenty-member taste panels were unable to detect a statistically significant flavour difference between farmed and wild salmon (steamed and served cold) in three separate panels, with responses of 12/8, 11/9 and 12/8 in favour of the farmed samples. A preference ratio of at least 15/5 is required for statistical significance. However, the data do show a non-significant trend in favour of the farmed samples.

TABLE 6: Fat content (%) of farmed and wild salmon

<table>
<thead>
<tr>
<th>Samples</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmed - retail (n=308)</td>
<td>12.49</td>
<td>2.52</td>
</tr>
<tr>
<td>Farmed - fish farm (n=384)</td>
<td>11.50</td>
<td>2.36</td>
</tr>
<tr>
<td>Wild - retail (n=295)</td>
<td>12.25</td>
<td>3.01</td>
</tr>
</tbody>
</table>

1Number of salmon tested.
2105 additional salmon were tested for fat content.

TABLE 7: Percentage of salmon in different fat categories

<table>
<thead>
<tr>
<th>Fat (%) category</th>
<th>Farmed - retail (n=308)</th>
<th>Farmed - fish farm (n=384)</th>
<th>Wild - retail (n=295)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>0.3</td>
<td>0.3</td>
<td>0</td>
</tr>
<tr>
<td>4 - 8</td>
<td>4.5</td>
<td>7.6</td>
<td>8.5</td>
</tr>
<tr>
<td>8 - 12</td>
<td>37.7</td>
<td>52.6</td>
<td>36.6</td>
</tr>
<tr>
<td>12 - 16</td>
<td>31.3</td>
<td>38.0</td>
<td>45.4</td>
</tr>
<tr>
<td>16 - 20</td>
<td>6.2</td>
<td>1.6</td>
<td>9.2</td>
</tr>
<tr>
<td>&gt;20</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
</tr>
</tbody>
</table>

3Number of salmon tested.
samples. The samples were carefully selected for similar fat contents, i.e. 13.6 vs 12.6% (panel 1), 14.8 vs 14.4% (panel 2) and 14.0 vs 14.4% (panel 3) thus eliminating fat as a factor influencing flavour.

Portions from the salmon tasted by the panelists were sheared (100 g of steamed salmon cooled to 15°C; Kramer shear cell) and tested for colour (hue angle; Hunter colour meter). The results (Table 8) show that the wild salmon had a firmer texture but a less pink colour (greater hue angle) than the farmed samples. The difference in texture may be a muscle-tone effect in the wild fish (i.e. more swimming) while the colour difference is a reflection of a higher pigment concentration in the diet of the farmed fish. It is important to stress that these tests were carried out on spot samples and a greater number of samples should be tested for conclusive flavour, texture and colour results.

Conclusions
- The condition factor (CF) of wild salmon was higher than farmed.
- The CF is a useful and easily measured quality index for salmon, especially when combined with fat content and skin colour, and has application at fish-farm and retail levels.

Equations have been developed to convert CF (+gut) to CF (-gut) and vice-versa in wild and farmed salmon.

• CF (-gut) values of >0.90 are desirable for both wild and farmed salmon; CF (+gut) values should be >0.96 (wild) and >0.98 (farmed).
• Ideally the salmon skin colour mean value should be <1.33 (based on a sample of at least 12 fish) and using a visual scoring system where 1 = silver; 2 = slightly yellow/bronze; and 3 = yellow/bronze/red.
• Wild salmon (12.3%) had a slightly lower mean fat content than farmed (12.5%) but showed more variation in fat content (i.e. coefficient of variation of 24.6 vs 20.7%).
• Taste panels were unable to detect a statistically significant flavour difference between steamed samples of farmed and wild salmon.

Objective tests indicated that steamed wild salmon had a firmer texture than farmed, while the flesh of the farmed fish was more pink/orange than the wild.

Acknowledgements
Thanks are extended to the Marine Institute, Bia Mara, Dunns (Fish and Poultry) Ltd and Superquinn Ltd for their assistance with these tests; also to the EU LEONARDO programme for the award of a grant to Ms. E. Schallich.

Ms. Evelyn Schallich from Hochschule, Bremerhaven, Germany, was a visiting researcher (EU LEONARDO programme) in the Department of Plant and Marine Foods, Teagasc, The National Food Centre, Dunsinea, Castleknock, Dublin 15. Dr. Ronan Gormley is Head of that Department.
Large quantities of Atlantic salmon, both farmed and wild are produced/caught in Ireland. While wild salmon are available, fresh, in quantity, for a relatively short period of the year (mostly June-August), the farmed fish are available fresh all year round. As a result, fresh salmon has now become a commodity product with frequent special offers being mounted by supermarkets. The fresh market requires well-conditioned salmon of uniform size while salmon smokers have the additional requirement of a narrow range in fat content. While most of the fish on offer are of a high quality, some poorly-conditioned fish find their way onto the market; in addition, the wide range in fat content between fish causes problems for smokers. Both of these aspects were addressed in a series of quality tests on 587 farmed and 295 wild salmon carried out at The National Food Centre (Teagasc) by Evelyn Schallich (a visiting researcher from Bremerhaven, Germany) and Ronan Gormley. The tests included condition factor, visual condition, fish maturity, fat content and taste panel assessment of flavour (spot samples only). Microbiological and spoilage aspects were not considered.

**Condition factor (CF)**

Salmon deplete their body reserves as they mature sexually and they become thin, i.e. they lose condition. This manifests itself as a loss of tissue fat, an increase in water content, and a paling of the flesh from rich pink/orange to light pink/white. The fish also loses its silver colour and becomes more bronze, and in advanced stages of maturity bronze/red. The condition factor (CF) is a useful index of condition as it relates fish length to weight. A CF of 0.75 indicates a very thin fish and a value of 1.25 a very well conditioned salmon. The test is simple, requiring only measuring the length and weight of each fish and entering the data into the CF equation i.e.

\[
CF = \frac{[\text{fish weight (g)} \times 100]}{[\text{fish length (cm)}]^3}
\]

Visual assessment was carried out by a single judge and the fat content was measured using a Torry fat meter.
Results and conclusions

- The condition factor (CF) of wild salmon was higher than farmed.

- The CF is a useful and easily-measured quality index for salmon, especially when combined with fat content and skin colour, and has application at fish-farm and retail levels.

- Equations have been developed to convert CF (+gut) to CF (-gut) and vice-versa in wild and farmed salmon.

- CF (-gut) values of >0.90 are desirable for both wild and farmed salmon; CF (+gut) values should be >0.96 (wild) and >0.98 (farmed).

- Ideally the salmon skin colour mean value should be <1.33 (based on a sample of at least 12 fish) and using a visual scoring system where 1 = silver; 2 = slightly yellow/bronze; and 3 = yellow/bronze/red.

- Wild salmon (12.3%) had a slightly lower mean fat content than farmed (12.5%) but showed more variation in fat content (i.e. coefficient of variation of 24.6 vs 20.7%).

- Taste panels were unable to detect a statistically significant flavour difference between steamed farmed and wild salmon served cold. Objective tests indicated that steamed wild salmon had a firmer texture than farmed, while the flesh of the farmed fish was more pink/orange than the wild.

The complete study has been published in Farm and Food, 1996, 6 (3), and a copy can be obtained from Dr Ronan Gormley at Teagasc, The National Food Centre, Dunsinea, Castleknock, Dublin 15. Tel: 01-8383222; Fax: 01-8383684.